Vermont Flood Plain Management Services

Dam-Break Flood Analysis
Chandler Pond Dam
Lyndonville, Vermont

August 1997

US Army Corps
of Engineers
New England Division

DAM-BREAK FLOOD ANALYSIS
CHANDLER POND DAM
LYNDONVILLE, VERMONT

PREPARED FOR
STATE OF VERMONT
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DAM SAFETY PROGRAM

PREPARED BY
WATER MANAGEMENT SECTION
ENGINEERING DIVISION

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT, NORTH ATLANTIC DIVISION
CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS 02254-9149

AUGUST 1997

DAM-BREAK FLOOD ANALYSIS
CHANDLER POND DAM
LYNDONVILLE, VERMONT

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

EMERGENCY ACTION PLAN

LIST OF TABLES

LIST OF PLATES

DAM-BREAK FLOOD ANALYSIS
CHANDLER POND DAM
LYNDONVILLE, VERMONT

EXECUTIVE SUMMARY

The primary purpose of this study is to determine the downstream hazard classification of Chandler Pond Dam for the Dam Safety Program under jurisdiction of the State of Vermont, Department of Environmental Conservation. The secondary purpose is to provide introductory information for the dam owner to develop an Emergency Action Plan (EAP) in the event of an impending dam failure.

Dam-break flood conditions are evaluated for both sunny-day and storm-day failures. The analyzed storm events include the 100-year recurrent storm and variations of the Probable Maximum Flood (1/4, 1/2, 3/4, and full PMF). The PMF is defined as the maximum precipitation of a given duration, that is physically possible over a given size storm area at a particular geographical location and a certain time of the year.

Inflow hydrographs and spillway hydraulic capacity are developed as a basis upon which to model the breach discharge. Peak inflows are routed through the reservoir using the National Weather Service DAMBRK flood forecasting model. Breach discharge hydrographs for a sunny-day and a full PMF storm-day are routed through the downstream channel for a distance of approximately 3.5 miles below the dam. Limits of inundation are delineated in plan and profile view.

On the basis of U.S. Army Corps of Engineers guidelines for safety inspection, the dam's size classification is INTERMEDIATE. On the basis of its potential to cause downstream damage, in terms of either loss of life or economic loss, Chandler Pond Dam is rated Class 2 or a SIGNIFICANT hazard category.

Four major components of an EAP are discussed: monitoring, evaluation, preventive action, and warning. Official contacts are provided in the event of an impending dam failure.

DAM-BREAK FLOOD ANALYSIS
CHANDLER POND DAM
LYNDONVILLE, VERMONT

1. INTRODUCTION

a. Purpose. This study was conducted to estimate downstream flood levels and determine the hazard classification of Chandler Pond Dam, for the State of Vermont, Department of Environmental Conservation, Dam Safety Program. A secondary purpose is to provide information for use by the dam owner in developing an Emergency Action Plan (EAP) in the event of an impending dam failure.

The study provides findings for various assumed dam-break flood conditions for the Chandler Pond Dam with resulting downstream effects. Findings include the development of storm inflows above the dam, mechanisms that trigger the failure of the dam, resulting breach discharges, and delineation of downstream flooded limits. This study investigated the results of a hypothetical dam-break at Chandler Pond, not any expected failure of the dam.

b. Authority. This study was performed by the Corps of Engineers under its Flood Plain Management Services (FPMS) Program authorized in section 206 of the Flood Control Act of 1960, at the request of the State of Vermont, Department of Environmental Conservation.

c. Downstream Hazard Classification. Dams are classified according to the potential for loss of life and property damage in the areas downstream of a dam if it were to fail. The hazard classification does not refer to the condition of the dam.

The classification system used in this study has been adopted by the U.S. Army Corps of Engineers and is used by the Department of Environmental Conservation to determine inspection frequency and spillway adequacy for dams under its jurisdiction. The hazard classifications follow:

DOWNSTREAM HAZARD CLASSIFICATION OF DAMS

Class	Potential Hazard Category	Loss of Life (Extent of Development)	Potential Economic loss (Extent of Development)
3	Low	None Expected (No permanent structure for human habitation)	Minimal (Undeveloped, occasional structures or agriculture)
2	Significant	Few (no urban development and no more than a small number of inhabitable structures)	Appreciable (notable agriculture, industry, or structures)
1	High	More than a few	Excessive (extensive community, industry, or agriculture)

Under the Corps system, the classifications are further described:

(1) LOW Hazard (Class 3). Dams conforming to criteria for the low hazard potential category generally will be located in rural or agricultural areas where failure may damage farm buildings, limited agricultural land, or township and country roads.

(2) SIGNIFICANT Hazard (Class 2). Significant hazard potential category structures will be those located in predominantly rural or agricultural areas where failure may damage isolated homes, secondary highways or minor railroads or cause interruption of use or service of relatively important public utilities.

(3) HIGH Hazard (Class 1). Dams in the high hazard potential category will be those where failure may cause serious damage to homes, extensive agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads.

In addition, it is important to understand the following:

(1) The terminology HIGH, SIGNIFICANT, AND LOW hazard refers to the potential for damage or loss of life and does not refer to the condition of the dam. For example, a HIGH hazard (class 1) dam may be in excellent condition and a LOW hazard (class 3) dam may be in poor condition.

(2) A dam's classification may change from what is was when constructed, or at the last inspection because of changes in downstream conditions. For example, a class 3 (low hazard) dam may become a class 2 (significant hazard) or class 1 (high hazard) dam if houses are built downstream that could be impacted by a failure. The classification could also change (either up or down) if a more detailed breach analysis is carried out that more accurately determines downstream damage potential.

(3) It should not be assumed that the failure of a class 3 (low hazard) dam would never be a threat to lives. Although direct loss of life (such as by flooding a house) is not expected, the failure could for example wash out a road, resulting in a fatal accident.

2. PROJECT DESCRIPTION

a. General. Chandler Pond Dam is located approximately 3,000 feet upstream of South Wheelock Branch Brook near the town of Lyndon, Vermont (see plate 1). Constructed in the late 19th century, the dam's spillway was renovated in 1962. The dam, owned and operated by the Village of Lyndonville, was originally built for water supply. Presently, it is not being used for that purpose.

The dam is an earthfill with a core wall structure with an overall crest length of 450 feet at elevation 1,263.5 feet National Geodetic Vertical Datum (NGVD). It has an uncontrolled concrete ogee spillway with crest elevation at 1,256.0 feet NGVD and 20 feet in length. The structure has a 16 inch diameter gaye valve which is in operable condition; however, under normal conditions this gate is closed.

b. Community Description. The nearest town downstream of Chandler Pond Dam is Lyndon. It is located in the Passumpsic River valley approximately 35 miles below the Canadian border in central Caledonia County. Lyndon is bordered by the town of Burke to the north, and the town of Wheelock to the west.

c. Downstream Conditions. The area investigated for potential flooding is located along the South Wheelock Branch Brook, a tributary to the Passumpsic River. The unnamed brook that feeds Chandler Pond is a tributary of South Wheelock Branch Brook.

The study area is primarily hilly with some agricultural use and a few residences in the flood plain. The flood plain is generally very narrow, with the exception of the area where the brook from Chandler Pond Dam joins South Wheelock Branch Brook. Channel bottom elevations downstream of the dam and at the confluence with South Wheelock Branch Brook are 1,246.0 and 1,226.0 feet NGVD, respectively. This results in a drop in elevation of 20.0 feet over the 3,000-foot reach. Elevations from the confluence of the South Wheelock Branch Brook and its confluence with the Passumpsic River (a stream distance of 26,000 feet) drop from 1,226.0 to 680.0 feet NGVD, an average slope of 110.0 feet per mile. Downstream from the limits of detailed study, the last 4,200 feet of brook, have flood plain boundaries delineated as the result of a Flood Insurance Study (FIS) for the town of Lyndon in 17 May 1988.

This brook flows through a narrow channel with varying channel slopes which at some locations are as high as 360.0 feet/mile. The reach starting at Chandler Pond Dam and ending at the confluence with the Passumpsic River is approximately 29,000 feet in length. Detailed analysis of the initial 18,500 feet was conducted in this study. Limits of the detailed study reach are shown in Plate 1.

Downstream of the dam and before the confluence with South Wheelock Branch Brook, flows pass through two structures: a 60-inch diameter conduit with road and invert elevations of 1,248.5 and 1,240.5 feet NGVD, respectively, and a 72-inch diameter conduit with road and invert elevations of 1,240.2 and 1,224.0 feet NGVD respectively.

Between the confluence with South Wheelock Branch Brook and the Passumpsic River, there are several bridge structures. Top of road elevations for the first four bridges were surveyed aerially; stream invert elevations at these locations were measured from the top of the road during a site visit conducted in June 1996. Information on the remaining bridges was taken from the FIS for the town of Lyndon, Vermont. Table 1 shows pertinent information on all structures in South Wheelock Branch Brook. Location of bridges and structures is shown in Plate 1.

3. DAM DESCRIPTION (DATA OBTAINED FROM THE VERMONT INVENTORY OF DAMS UNLESS OTHERWISE NOTED)

a. Identification. The national inventory prepared by the U.S. Army Corps of Engineers identifies this impoundment as VT00095. The structure is owned by the village of Lyndonville, Vermont.

b. Physical Characteristics.

Type: Earthfill w/Corewall
Length: Approximately 450 feet
Height: Approximately 17.5 feet
Top Width: Varies

TABLE 1

CHANDLER POND DAM
LYNDONVILLE, VERMONT

BRIDGE ELEVATION DATA

Bridge Description	Distance from Chandler Pond (feet)	Top of Road Elevation (feet NGVD)	Invert Elevation (feet NGVD)
1	8,600	997.3 *	985.0 **
2 Bean Pond Brook Confluence	12,405	914.0 *	903.0 **
3	15,400	879.0 *	868.0 **
4 Cold Hill Brook Confluence	18,000	846.2 *	832.0 **
5 Covered Bridge 1 Mill Street	24,700	741.2 ***	715.0 ***
6 Cross Street	25,900	706.5 ***	695.7 ***
7 Covered Bridge 2	27,840	701.4 ***	691.0 ***
8 Town HW-1	27,900	709.7 ***	691.9 ***
9 Interstate HW-91	28,300	733.0 ***	689.0 ***

* Surveyed elevation
** Estimated, measured during site visit
*** Taken from FIS information

c. Outlets. A low level 16 inch diameter gate valve is located at the east side of the structure on the downstream side of the dam and approximately six feet below spillway elevation. Invert of the gate is located at 1,250.0 feet NGVD. The gate is in operable condition, but kept in a closed position.

d. Impoundment Behind Dam
(Information based on June 1996 survey)

Surface Area:	103 acres at top of dam
Height of Dam:	17.5 feet at structural height 10 feet at spillway height
Estimated Storage Volume:	440 acre-feet at normal elevation 1,080 acre-feet at top of dam

e. Pertinent Elevations

Top of Dam:	1,263.5 feet NGVD
Spillway:	1,256.0 feet NGVD
Invert at Centerline of Dam	1,246.0 feet NGVD
Low level drain downstream invert:	1,250.0 feet NGVD

f. Watershed Area.

Size: 1.7 square miles (from USGS topographic quadrangles)

Type: Mostly forested with steep slopes

4. METHOD OF ANALYSIS

a. Introduction. Two types of dam failure simulations were conducted for this study: sunny and storm day failures.

A sunny-day failure refers to a failure under normal water level usually associated with fair weather or non flood conditions. Piping is the progressive internal erosion of a soil mass such as an embankment, foundation, or abutment of a dam from uncontrolled seepage carrying soil particles to an unprotected exit that over time creates an erosion cavity or pipe. Once this occurs, a rapid failure of the dam could release contents of the reservoir and form the breach discharge. Piping is the most common cause of sunny-day failures on earth dams and others that are constructed on earth foundations or abutments. A sunny-day failure can also result from other causes, such as a sudden failure of a conduit under pressure or a structural component of the dam.

A storm-day failure is associated with major storm events and floods. During periods of significant rainfall and resulting runoff, the impoundment will rise to high levels. If the storm is severe enough and inflow exceeds the hydraulic capacity of the spillway and reservoir storage capacity, overtopping of the embankment can occur. As floodwaters flow over the dam, erosion of the earth embankment or abutments can occur, resulting in a failure of the dam and formation of the breach discharge as contents of the reservoir are released. High reservoir levels associated with overtopping of the dam, can also result in other failure modes, such as piping, sudden structural or progressive failures of stone or masonry elements.

b. Hydrology. To accomplish dam-break analyses, an inflow hydrograph to Chandler Pond resulting from a 100-year storm and four fractions (1, 3/4, 1/2, 1/4) of the probable maximum flood (PMF) were developed. Information necessary for generating the hydrographs include rainfall data and unit hydrograph characteristics.

Rainfall data for the 100-year storm were obtained from the National Weather Service Technical Paper 40, "Rainfall Frequency Atlas of the United States." To develop a worst case distribution, the 24-hour duration rainfall data were critically arrayed so that the peak occurred at the twelfth hour, preceded by the second largest rainfall increment, and followed by the third largest. Total 24-hour, 100-year precipitation for this location is 5.60 inches.

The PMF was developed from the probable maximum precipitation (PMP). Hydrometeorological Reports 51 and 52 provided the rainfall data and guidelines for applying it, and the Corps computer program HMR52 was used to develop the PMP for this watershed. The peak 24-hour rainfall was taken from the derived 72-hour PMP and critically arrayed similarly to the 100-year rainfall. The total 24-hour PMP is 26.65 inches, with a peak one-hour increment of 12.46 inches.

Runoff from these rainfall events was developed using the Corps computer model HEC-1. Inflow hydrographs were developed using the SCS method which accounts for soil permeability and rainfall losses with a single parameter, runoff curve number (CN). For this heavily wooded watershed a CN of 55 was adopted. The lag time for the watershed, based on overland slope and flow length, was computed to be 2.1 hours.

Since this analysis was geared to address the dambreak impact on the South Wheelock Branch Brook area, additional hydrologic analysis was required to account for the discharges from the section of the South Wheelock Branch Brook upstream of the confluence with Chandler Pond Brook. This watershed has a drainage area of 7.1 square miles.

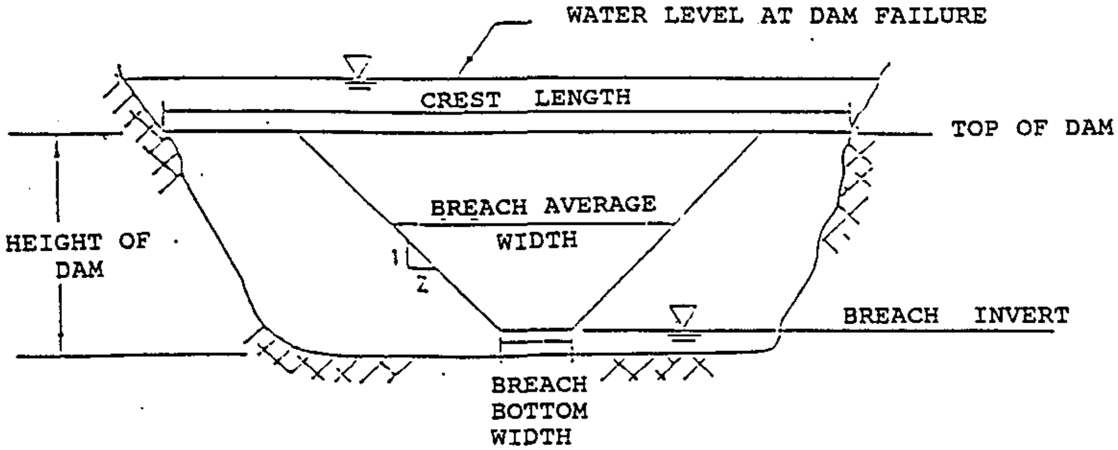
A reasonable assumption is that a PMP centered over the Chandler Pond Dam drainage area would produce residual rainfall and runoff in surrounding areas. For this reason and using the HMR52 program, residual PMP analysis of the upper 7.1 square miles of South Wheelock Branch Brook was developed. Again, four fractions of the residual PMP (1, 3/4, 1/2 and 1/4) were used. The peak 24-hour rainfall was taken from the derived 72-hour residual PMP and critically arrayed in a similar fashion to the Chandler Pond Dam development. The total 24-hour residual PMP is 21.2 inches, with a peak one-hour increment of 7.73 inches.

Runoff for the residual PMP rainfall was developed using the Corps computer model HEC-1. Runoff hydrographs were developed using the SCS method with a CN number of 55 and a lag time of 4.0 hours. The developed hydrographs were used as lateral inflow at the confluence of South Wheelock Branch Brook with Chandler Pond Dam brook.

c. Reservoir Routing. The inflow hydrographs were routed through the reservoir to obtain outflow flood hydrographs based on the storage and outlet capacities of the dam. Initial reservoir routing was performed using HEC-1 assuming the dam does not breach. Modified puls (storage) routing was used to determine which inflows (100-year and fractions of PMF) cause overtopping of the dam, which in turn might lead to dam breach. This inflow was then adopted for the storm-day scenario. The storm-day and sunny-day dam-breaks were analyzed using the National Weather Service (NWS) DAMBRK computer program, which solves the complete unsteady flow equations.

d. Spillway Hydraulic Capacity. A rating curve for the Chandler Pond Dam was developed based on geometry of the spillway and dam. For pool levels greater than the top of dam elevation, 1,263.5 feet NGVD, an approximate geometry of the non-overflow sections at the east and west abutments was determined using 2-foot contour mapping. Flows through the gate were considered negligible since this gate is relatively small and operable but usually closed. Discharge rating curves were determined for flows over the spillway and top of dam using the weir equation. This overflow rating curve was used in routing the inflow hydrographs through the reservoir with the HEC-1 model.

e. Breach Discharge Hydrograph. The discharge hydrograph of a breach is a function of the inflow hydrograph and breach parameters of a hypothetical dam failure, i.e., time of breach formation, and size and shape of breach. The following sketch illustrates the various dam breach parameters for a typical earthen or concrete gravity dam. Total outflow is a combination of flows throughout the breach and spillway. As the breach develops, so does the breach discharge.



DEFINITION OF BREACH PARAMETERS

f. Assumed Breach Parameters

Assumed Sunny-Day Failure Condition

Initial Pool Level: Spillway crest 1,256.0 feet NGVD

Dam Failure Level: El. 1,256.1 feet NGVD

Breach Invert: 1,247 feet NGVD

Breach Bottom Width: 65 feet with side slope 1V:0H

Time to complete formation of Breach: 0.3 hour

Downstream Reach Roughness (Manning's "n" Values):

Channel = 0.05 to 0.065
Overbank = 0.08 to 0.10

Embankment Geometry:
Height of Dam = 10.0 feet at spillway
17.5 feet at top of dam

Crest Length = spillway = 20 feet
top of dam = 450 feet

Assumed Storm-Day Failure Condition

Initial Pool Level: El. 1,264.8 feet NGVD

Dam Failure Level: El. 1,265.0 feet NGVD

Breach Invert: El. 1,247.0 feet NGVD

Breach Bottom Width: 45 feet with side slope 1V:1H

Time to Complete Formation of Breach: 0.5 hour

Downstream Reach Roughness (Manning's "n" Values):

Channel = 0.05 to 0.065
Overbank = 0.08 to 0.10

Embankment Geometry:

Height of Dam = 10.0 feet at spillway
17.5 feet at top of dam

Crest Length = spillway = 20 feet
top of dam = 450 feet

g. Downstream Channel Routing. A downstream channel routing analysis allows the breach discharge hydrograph to be characterized at points of interest below the dam. A breach hydrograph is attenuated and stored through a downstream channel and flood plain in a manner similar to that where an inflow hydrograph is routed through a reservoir. The degree where this breach discharge is attenuated is a function of the downstream valley storage capacity and valley roughness characteristics.

The dynamic wave method of channel routing is used in the NWS DAMBRK computer program to route the flood wave downstream. This is a hydraulic routing method that solves the complete unsteady flow equations through a given reach. Results of this method indicate attenuation of the flood wave, resulting flood stages, and the time it takes the wave to reach the section.

Downstream valley storage was determined using cross sections developed from 2-foot contour mapping and USGS topographic quadrangles. Based on field observations, assigned Manning's "n" values ranged between 0.05 and 0.065 for channel, and 0.08 and 0.1 for overbanks.

The downstream channel routing procedure is based on the assumption that flow structures below the dam (i.e., conduits, bridges, etc) do not become blocked with debris. The hydraulic rating data for these structures assumes full hydraulic capacity. If structures become blocked with debris, the peak water surface elevation behind them could increase to stages higher than estimated.

In addition, all flow structures were assumed not to fail in the dam-break computer model in order to estimate the maximum water levels expected. However, due to the increased flood stages and velocities associated with a dam break, failure of any or all these structures is possible. This study does not attempt to determine if any downstream structures will fail during a dam-break at Chandler Pond Dam.

In order for the NWS DAMBRK model to mathematically converge for initial (antecedent) conditions, a minimum amount of flow is required. The initial channel flow for the sunny-day condition was assumed to be 60 cfs. This was the minimum flow for which the program converged. Based on water resource data supplied by the USGS, the mean annual runoff for this region of the country is approximately 1.8 cfs/square mile of drainage area, so the estimated mean annual flow for Chandler Pond Dam and South Wheelock Branch Brook are approximately 3 and 13 cfs respectively. As can be seen the adopted initial flows of 60 cfs is considerably greater than the estimated mean annual flow for the reach. This flow however is insignificant compared to peak dam break flows and would not impact the peak flood level predicted.

For storm-day routing, initial flows were those associated with the storm-day flood hydrograph just prior to dam failure. The dam was assumed to fail at the peak elevation and outflow for the full PMF for Chandler Pond.

h. Project Mapping. For this study the USGS quadrangle map for Lyndonville, VT, scale 1:24000 was used. This map is listed as provisional and dated 1986. In addition, a 2-foot contour map (scale = 1 inch : 100 feet) was developed specifically for this study. This mapping extends 3.5 miles downstream of the Chandler Pond Dam.

Location of structures within inundation limits was verified through field visits, site reconnaissance, and limited FIS information for the town of Lyndon, Vermont.

i. Vertical Control. Vertical control for this investigation was obtained by the Vermont Agency of Transportation and Eastern Topographic of Wolfeboro, NH, using global positioning system. A new monument was installed on the left side of the spillway abutment as part of this effort.

5. RESULTS OF ANALYSIS

a. Inflow Hydrograph. Results of the 100-year storm event and various percentages of the PMF for Chandler Pond Dam are presented in Table 2. The peak inflow resulting from a full PMF is 4,600 cfs. Inflow hydrographs for the 100-year and PMF are presented in Plates 2 and 3, respectively. For the two events peak occurs at around 16 hours in a 24-hour storm. These hydrographs were developed using the HEC-1 computer program.

TABLE 2

CHANDLER POND DAM
LYNDONVILLE, VERMONT
(Drainage Area 1.7 square miles)

100-Year and PMF Inflow Reservoir Routing Summary

Flood Frequency	Peak Inflow (cfs)	Peak Outflow * (cfs)	Maximum Pool Level (feet-NGVD)	Available Freeboard ** (feet)
100-Year	270	100	1,257.0	6.5
1/4 PMF	560	200	1,258.2	5.3
1/2 PMF	1,800	600	1,260.8	2.7
3/4 PMF	3,200	1,400	1,263.3	.2
Full PMF	4,620	3,800	1,264.8	overtopped

* Discharge computed using HEC-1; nonfailure assumed
** Freeboard measured from maximum pool level to top of dam (1,263.5 feet NGVD)

b. Reservoir Storage Capacity. An area capacity curve for Chandler Pond was developed using information provided by State officials. The maximum storage capacity at the top of dam, elevation 1,263.5 feet NGVD is approximately 1,080 acre-feet, and the storage capacity at normal pool elevation of 1,256.0 feet NGVD is approximately 440 acre-feet. These values were obtained using the State of Vermont Inventory Sheet for Chandler Pond Dam, and 2-foot contour mapping developed for this study. A phase I Inspection for Chandler Pond Dam has not been performed. As determined from the PMF inflow hydrograph analysis, the one-fourth, one-half, and three-fourths PMF do not overtop the dam. Maximum stage for the three-fourths PMF was determined to be 1,263.3 feet NGVD which is about 0.2 foot below the top of dam, and results in a storage of 1,000 acre-feet. The full PMF is the only flood analyzed that results in overtopping of the dam. Maximum stage with the full PMF is 1,264.8 feet NGVD, about 1.3 feet above the top of dam and resulting in 1,126 acre-feet of storage.

c. Spillway Hydraulic Capacity. Using the conventional weir equation with an assumed weir coefficient of 3.5 the maximum spillway hydraulic capacity at the top of the dam is estimated to be approximately 1,440 cfs. This discharge represents flow over the spillway only. Therefore, Chandler Pond Dam appears to have sufficient spillway capacity to adequately store and pass major flood events without overtopping the dam.

d. Breach Discharge Hydrograph. Tables 3 and 4 summarize the peak discharge and downstream channel routing results assuming sunny and storm-day failures, respectively.

Sunny-day failure of Chandler Pond Dam resulted in a peak breach discharge of approximately 3,700 cfs. The assumed water surface was at spillway crest, elevation 1,256.0 feet NGVD when failure began, and the breach was modeled to develop fully within 20 minutes. Plates 4 and 5 show sunny-day breach discharges and flow depth hydrographs at several downstream locations.

Storm-day failure results in a peak breach discharge of about 10,800 cfs with the full PMF storm initial inflow. Failure is modeled to begin at the peak of the outflow hydrograph, which corresponds to an elevation of 1,264.8 feet NGVD (1.3 feet over top of dam), and the breach is assumed to develop within 30 minutes. Plates 6 and 7 show the storm-day discharge and flow depth hydrograph at several downstream locations.

6. DOWNSTREAM CHANNEL ROUTING

Plates 8 and 9 show peak water surface profiles resulting from both the sunny and storm-day failure scenarios.

a. Sunny-Day Results. The sunny-day peak breach discharge is estimated by DAMBRK model to be 3,700 cfs. This results in overtopping of the 60 and the 72 inch culverts immediately downstream of the dam.

Discharges at the end of the modelled reach were determined to be approximately 2,500 cfs. A comparison was made between dambreak peak discharge of 2,500 cfs at the end of the study reach, and FIS information for the town of Lyndon (located about one mile downstream from the end of the study). Assuming no further attenuation of the flood wave from the end of this study reach to the beginning of the FIS reach, a flood level approximately equal to a FIS 50-year flood profile can be expected in the town of Lyndon.

Three structures along the right bank of the brook, all located about 2.3 miles downstream of Chandler Pond Dam near bridge 2 and the confluence with the Bean Pond Brook, appear to be within the flood plain. One barn at elevation 913 feet NGVD and two houses with first floor elevations 913 and 912 feet NGVD, respectively. At this location flood levels were predicted by the model to reach elevation 917 feet NGVD.

b. Storm-Day Results. The storm-day peak breach discharge of 10,800 cfs, estimated by the model, is attenuated in the first 0.6 mile to 9,900 cfs, with a drop in channel elevation of 136 feet. At this location, input from the South Wheelock Branch Brook increases peak discharges to 18,500 cfs.

Due to the major contribution of residual rainfall associated with the full PMF over Chandler Pond Dam, the prebreach flow for the South Wheelock Branch Brook is over 8,000 cfs. This results in very high prebreach flood levels. These levels range from about 8 feet to about 20 feet, above normal, at Chandler Pond Dam and at the brook's confluence, respectively. Since discharges are so high, there is little attenuation from the confluence to the end of the study reach.

It should be noted that due to the very high prebreach flow conditions, major flooding would be occurring with or without a failure of Chandler Pond Dam. For comparison purposes we note that the prebreach flow without a dam failure at the end of the study reach is over 11,400 cfs and the 500-year flow from the FIS for Lyndon, VT, is 4,600 cfs. Therefore, even without failure of the Chandler Pond Dam the prebreach flow is more than twice the 500-year flow adopted in the FIS.

In the detailed study area several locations appear to be affected by the storm day flooding. Following, is a detailed description of location, site elevation and flood level of affected locations.

(1) One house and one barn with first floor elevations at 1,116 and 1,112 feet NGVD, respectively, located at the confluence with the South Wheelock Branch Brook 0.562 mile downstream of the dam, would be flooded. Storm-day flood levels at this location, are estimated at 1,122.0 feet NGVD due to the added flows from the South Wheelock Branch Brook.

(2) Approximately 2.1 miles downstream of the dam, one house with first floor elevation at 933 feet NGVD would be flooded. At this location the storm-day flood levels were estimated to be 934 feet NGVD.

(3) Two sites, one house with first flood elevation 922 feet NGVD and a garage located approximately 2.2 miles downstream of the dam would be flooded. At this location the Storm-Day flood levels were estimated to be 927 feet NGVD.

(4) One barn at elevation 913 feet NGVD and two houses with first floor elevation 913 and 912 feet NGVD, respectively, located near bridge 2 at the confluence with Bean Pond Brook, about 2.3 miles downstream of the dam would be flooded. At this location the storm-day flood level was estimated to reach 922 feet NGVD.

(5) One house located 2.4 miles downstream of the dam with first floor elevation 908.5 feet NGVD would be impacted by storm-day flood which has a computed elevation of 914 feet NGVD.

(6) One house with first floor elevation 892 feet NGVD and a barn at elevation 887.3 feet NGVD located 2.7 miles downstream of the dam may be impacted by the storm-day flood which is estimated to reach elevation 892 feet NGVD.

(7) One barn with elevation 848 feet NGVD located approximately 3.36 miles downstream of the dam would be flooded because the floodwave reaches elevation 852 feet NGVD.

7. INUNDATION MAPPING

The limits of inundation were computed by routing the breach discharge hydrograph through the downstream valley cross sections and delineating the resulting maximum stages on the base map for the 3.5 miles analyzed. The map used is based on a 6-meter (approximately 20 feet) contour interval and, therefore, inundation limits shown on plates 10 through 13 are only approximate. Peak discharges for the sunny-day failure are somewhat similar to the computed FIS 50-year event in the downstream town of Lyndon. Therefore, an inundation level similar to the 50-year flood elevation can be expected at that location. All structures located within the 50-year flood plain as determined by FIS information may be impacted by the sunny-day failure.

Initial discharges at the downstream limit of the detailed study reach, for the storm-day failure scenario, were twice the amount of the 500-year event as presented in the town of Lyndon FIS. Therefore, flood levels between the analyzed 3.5 miles and the confluence of South Wheelock Branch Brook and the Passumpsic River are expected to be considerably higher than the computed FIS 500-year event. For this type of failure it is expected that, at a minimum, all the structures located within the FIS 500-year event flood plain will flood.

TABLE 3

CHANDLER POND DAM
LYNDONVILLE, VERMONT

DOWNSTREAM CHANNEL ROUTING RESULTS SUNNY-DAY FAILURE

Downstream Location	Peak Discharge (cfs)	Elevation (feet NGVD)	Depth Above Streambed (feet)	Time Peak (hours)
Chandler Pond Dam (0.0 mi)	3,700	1254.3	8.3	0.3
Bridge 1	2,900	992.7	8.7	0.8
Bridge 2 Bean Pond Brook Confluence	2,700	912.9	9.9	1.1
Bridge 3	2,500	876.6	7.6	1.3
Bridge 4 Cold Hill Brook Confluence	2,500	836.5	9.7	1.5

TABLE 4

CHANDLER POND DAM
LYNDONVILLE, VERMONT

DOWNSTREAM CHANNEL ROUTING RESULTS STORM-DAY FAILURE

Downstream Location	Peak Discharge (cfs)	Elevation (feet NGVD)	Depth Above Streambed (feet)	Time Peak (hours)
Chandler Pond Dam (0.0 mi)	10,800	1258.1	12.1	0.8
Bridge 1	17,700	999.4	15.4	1.0
Bridge 2 Bean Pond Brook Confluence	17,500	917.9	14.6	1.3
Bridge 3	17,300	884.9	15.5	1.4
Bridge 4 Cold Hill Brook Confluence	17,300	846.6	19.0	1.5

A more detailed map (1 inch : 100 feet) showing the limits of inundations and structures impacted, has been provided to the Department of Environmental Conservation under separate cover. Accuracy of the inundation mapping is restricted to the amount of survey data that were available for the study and model limitations. This includes limitations to the governing equations and uncertainty associated with some model parameters (i.e, Manning's "n" and breach parameters). In addition, high velocity flows associated with dam-break floods can cause significant scour of alluvial channels. Any enlargements in channel cross sections are not considered in the model.

8. SIZE CLASSIFICATION

Chandler Pond Dam is approximately 17.5 feet high from top of dam to the streambed invert elevation. The maximum available storage of the pool, at top of the dam, is approximately 1,080 acre-feet. The dam is considered "INTERMEDIATE" according to paragraph 2.1.1 of the Recommended Guidelines for Safety Inspection of Dams.

9. HAZARD CLASSIFICATION

On the basis of its potential to cause downstream damage, Chandler Pond dam is given a class 2 "SIGNIFICANT" hazard classification (refer to the Downstream Hazard Classification of Dams on page 2 of this report).

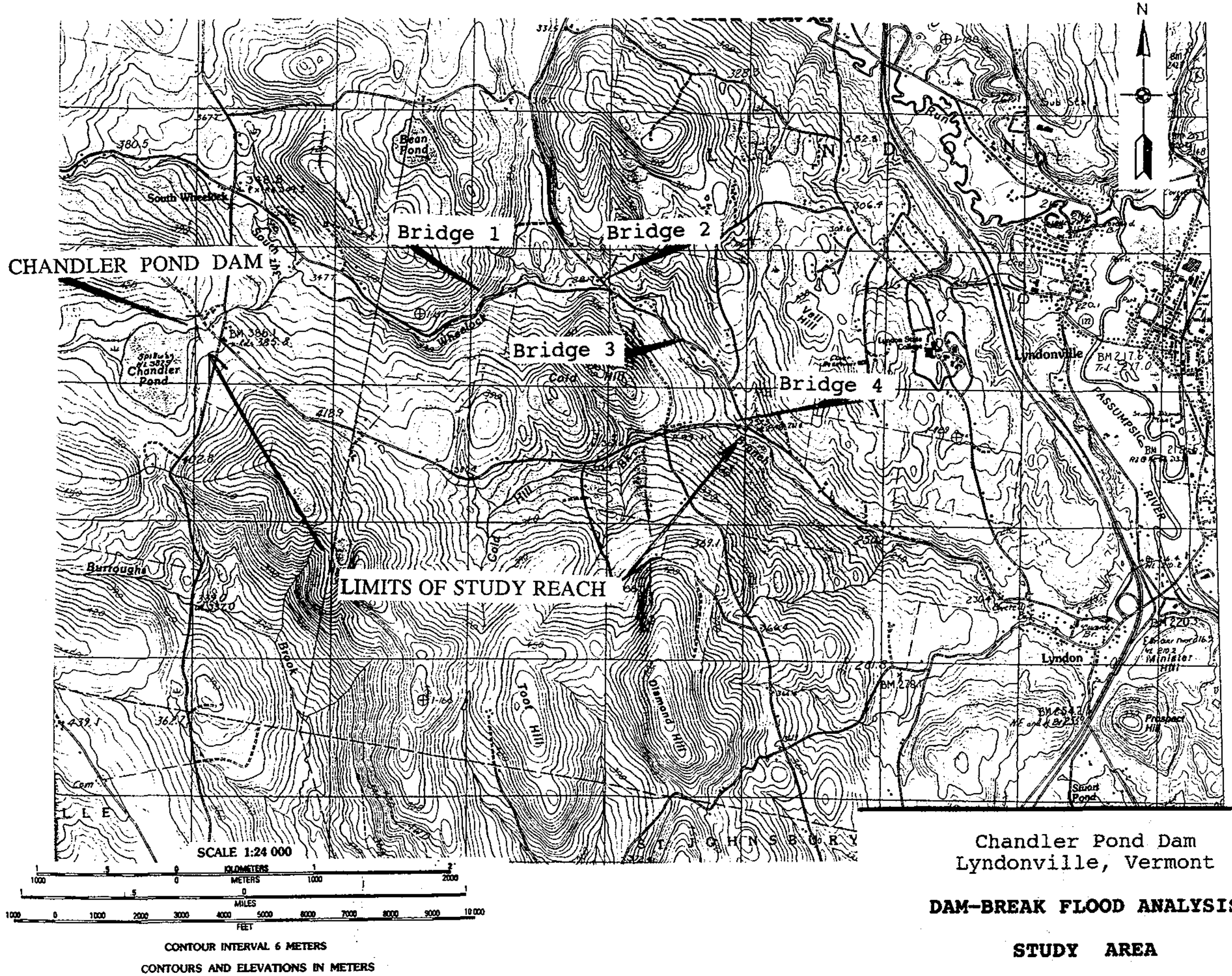
REFERENCES

1. U.S. Department of Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams," ER 1110-2-106, Washington, D.C., September 1979.

2. Federal Emergency Management Agency, "Flood Insurance Study, Lyndon, Vermont, County," 17 May 1988.

3. U.S. Geological Survey Water Supply Paper 2214, "Estimating Peak Discharges Of Small, Rural Streams."

4. DAMBRK, the NWS Dam-Break Flood Forecasting Model, Users Manual, November 1981.



Chandler Pond Dam
Lyndonville, Vermont

DAM-BREAK FLOOD ANALYSIS

STUDY AREA

PLATE 1

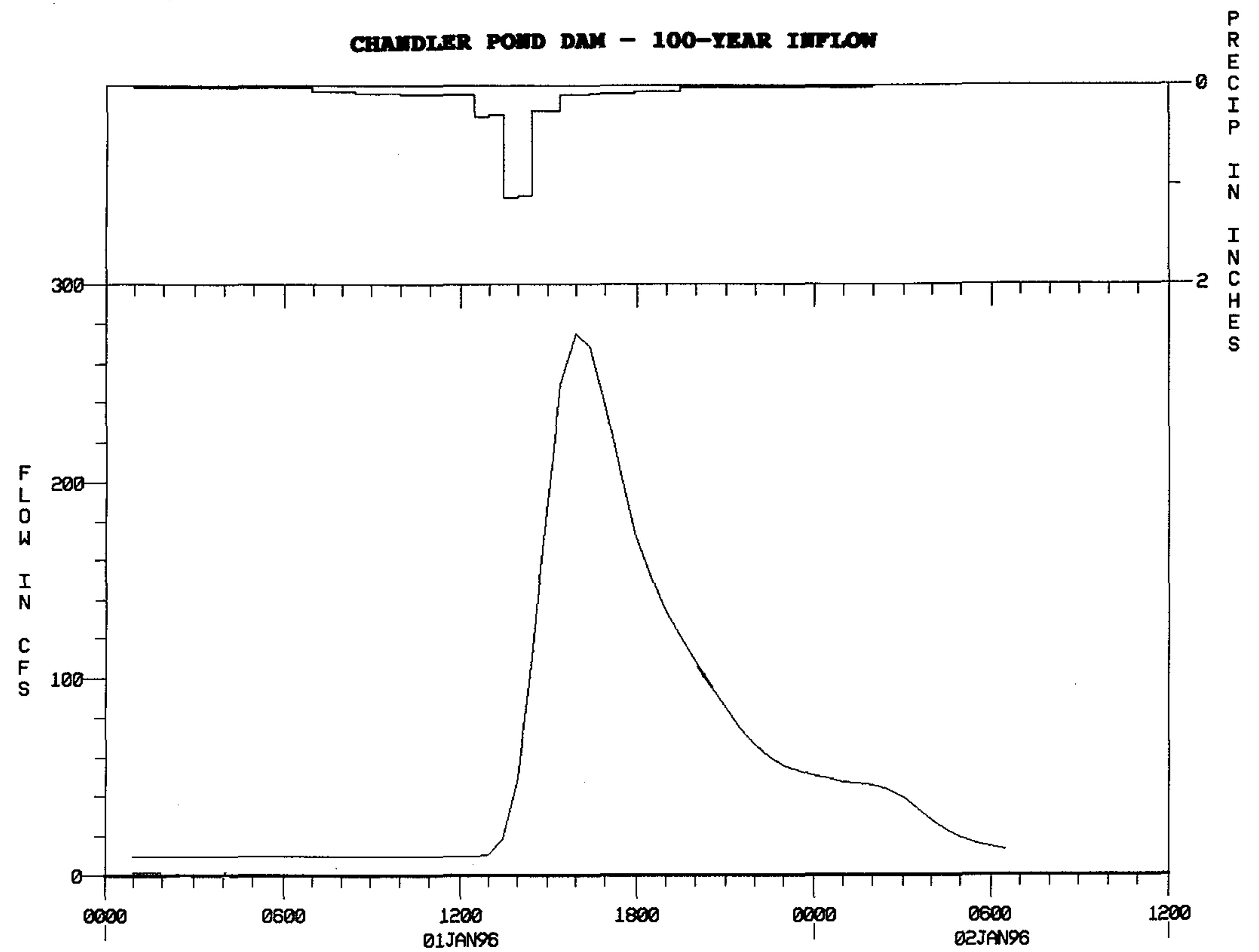

CHANDLER POND DAM - 100-YEAR INFLOW
PRECIP IN INCHES
0
2
FLOW IN CFS
300
200
100
0
0000
0600
1200
1800
0000
0600
1200
01JAN96
02JAN96

PLATE 2

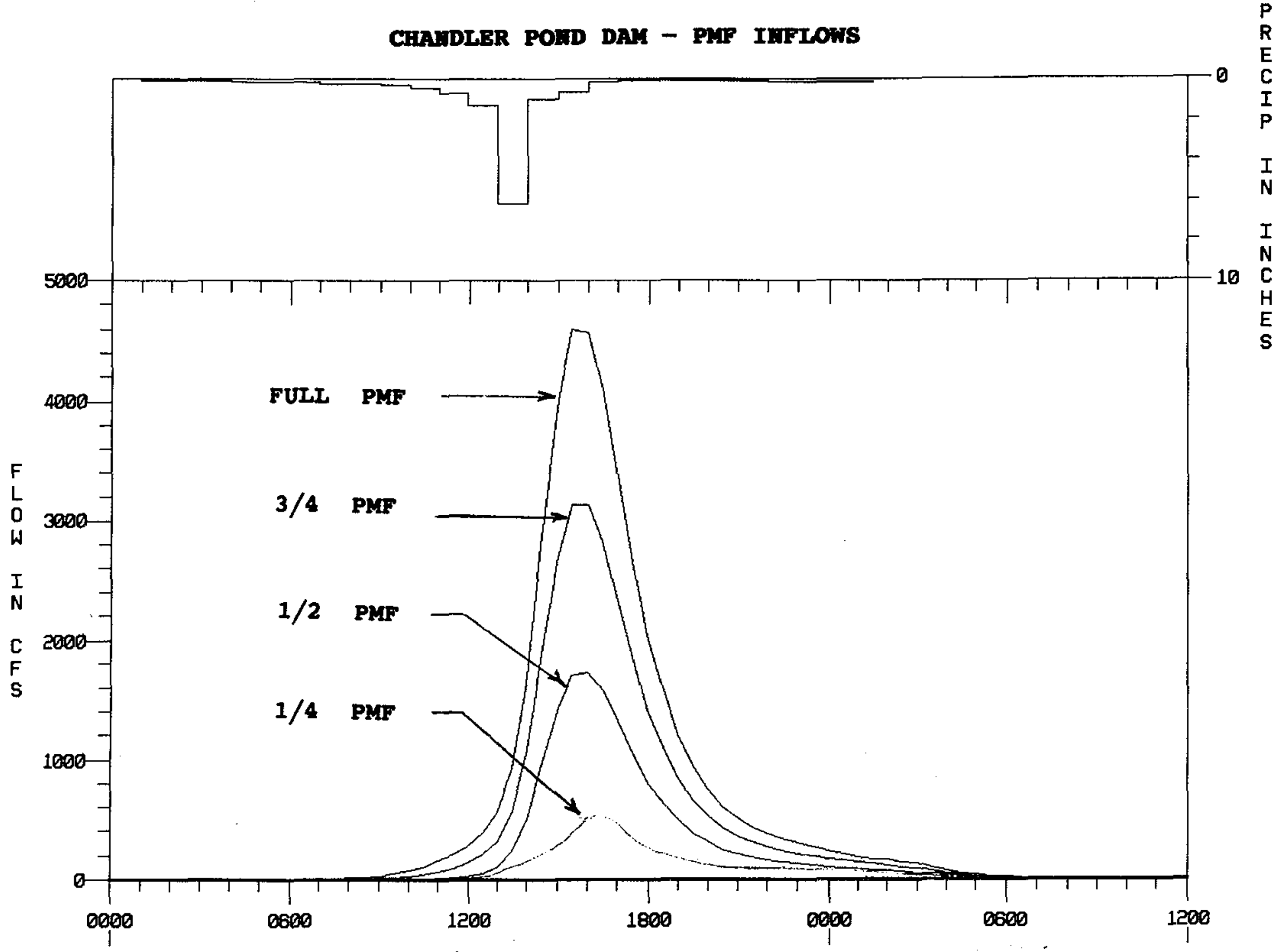

CHANDLER POND DAM - PMF INFLOWS
PRECIP IN INCHES
0
10
FLOW IN CFS
5000
4000
3000
2000
1000
0
FULL PMF
3/4 PMF
1/2 PMF
1/4 PMF
0000
0600
1200
1800
0000
0600
1200

PLATE 3

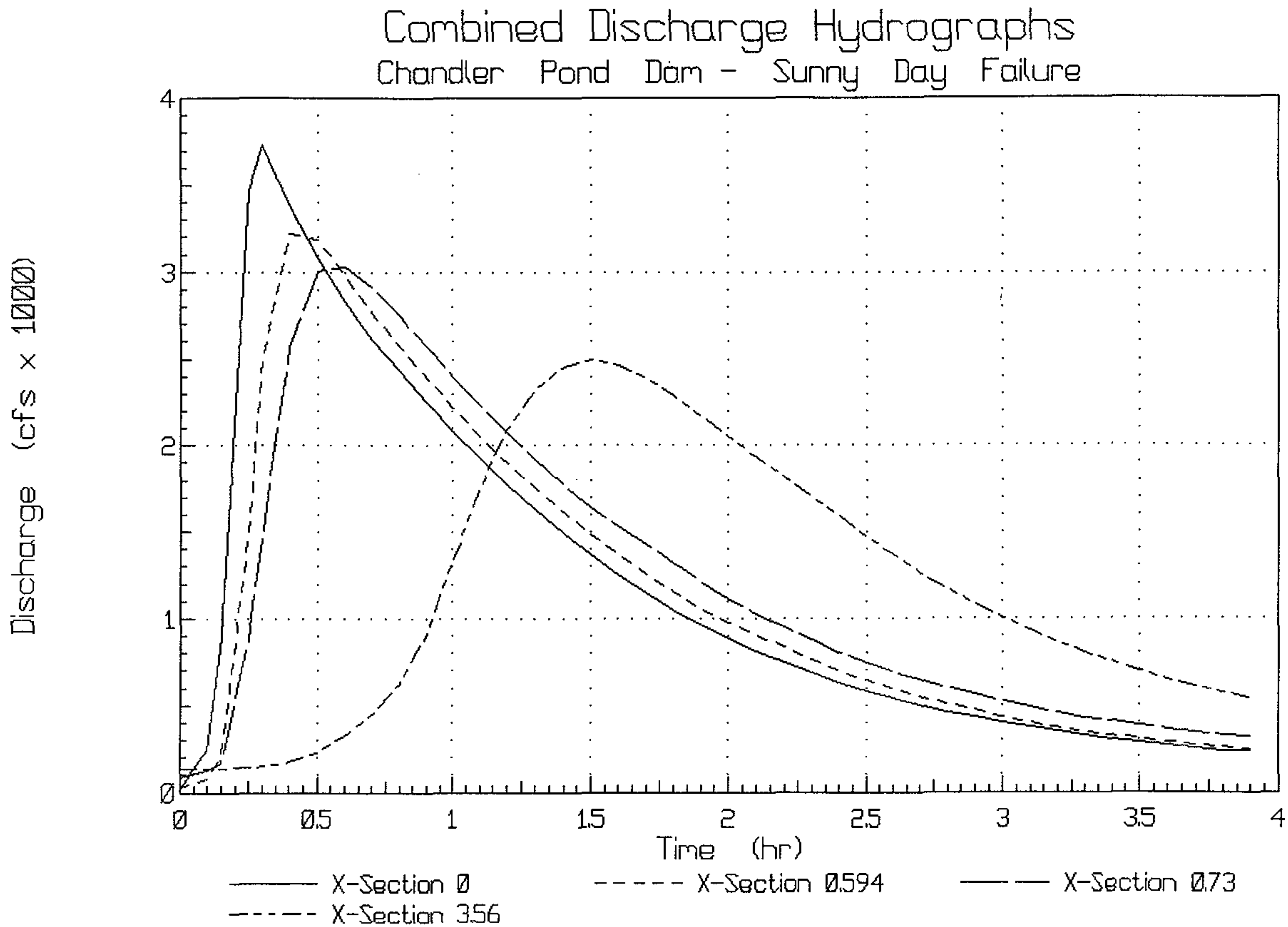
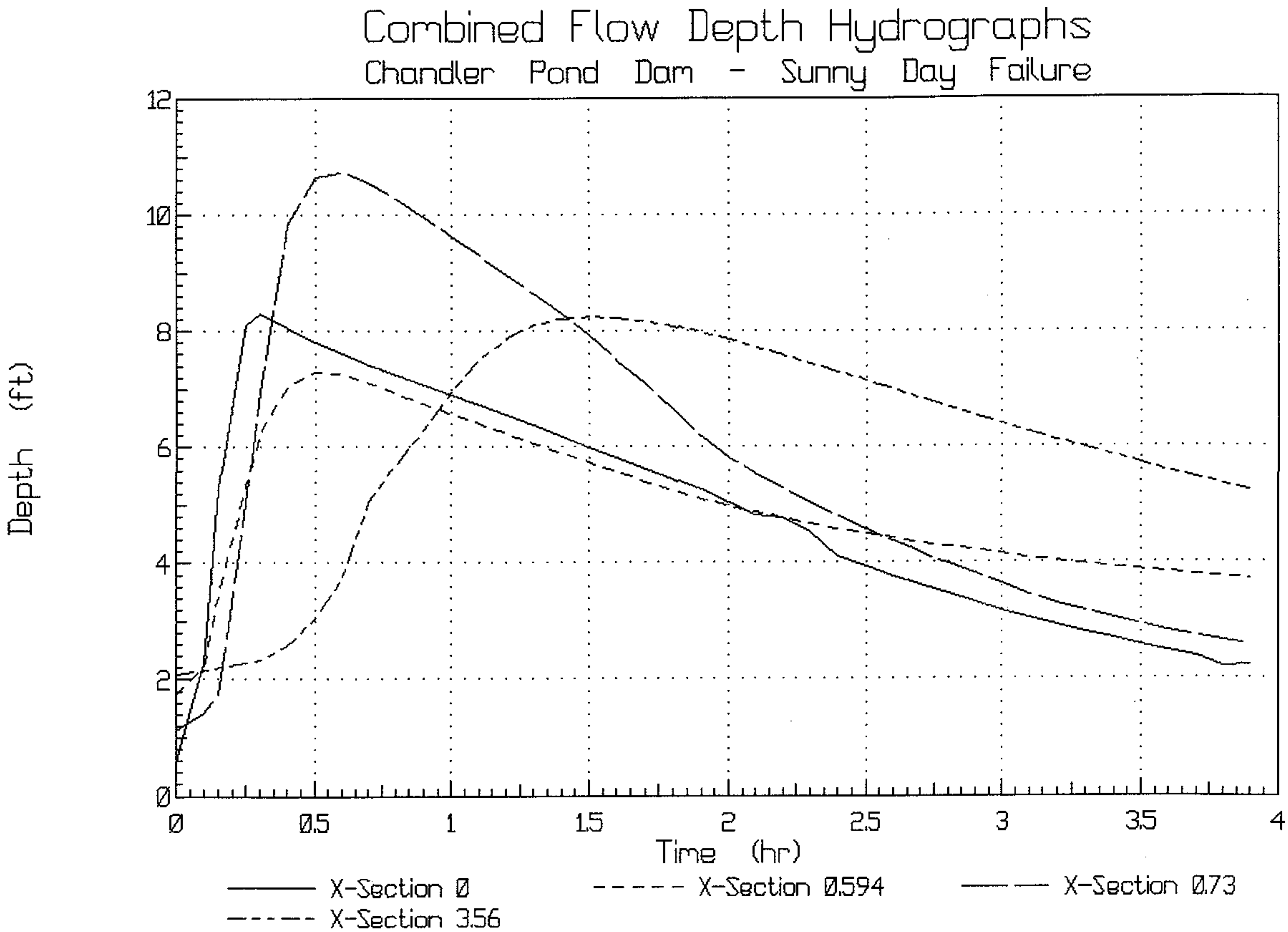
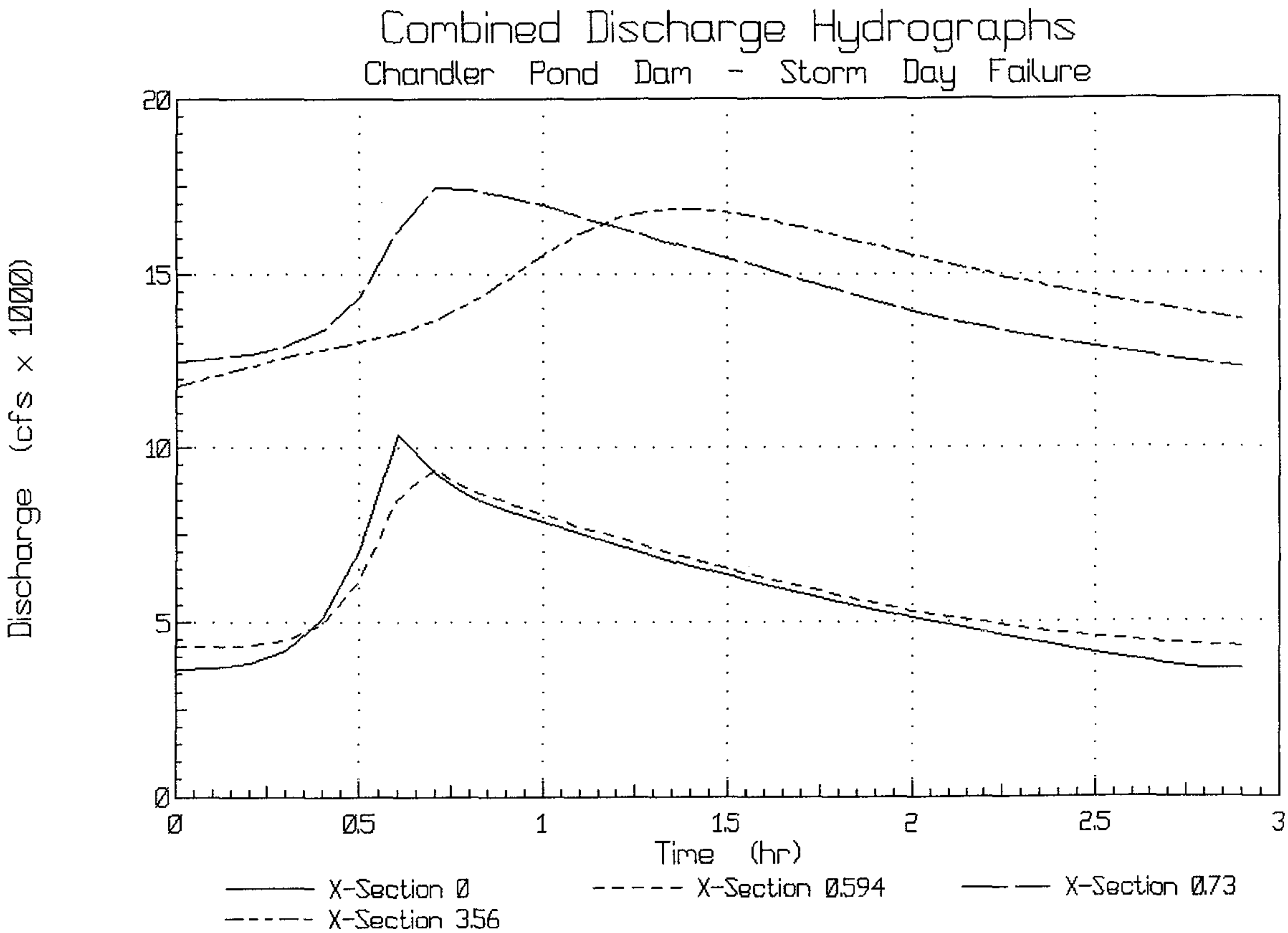

Combined Discharge Hydrographs
Chandler Pond Dam - Sunny Day Failure
Discharge (cfs x 1000)
0
1
2
3
4
0
0.5
1
1.5
2
2.5
3
3.5
4
Time (hr)
X-Section 0
X-Section 0.594
X-Section 0.73
X-Section 3.56

PLATE 4



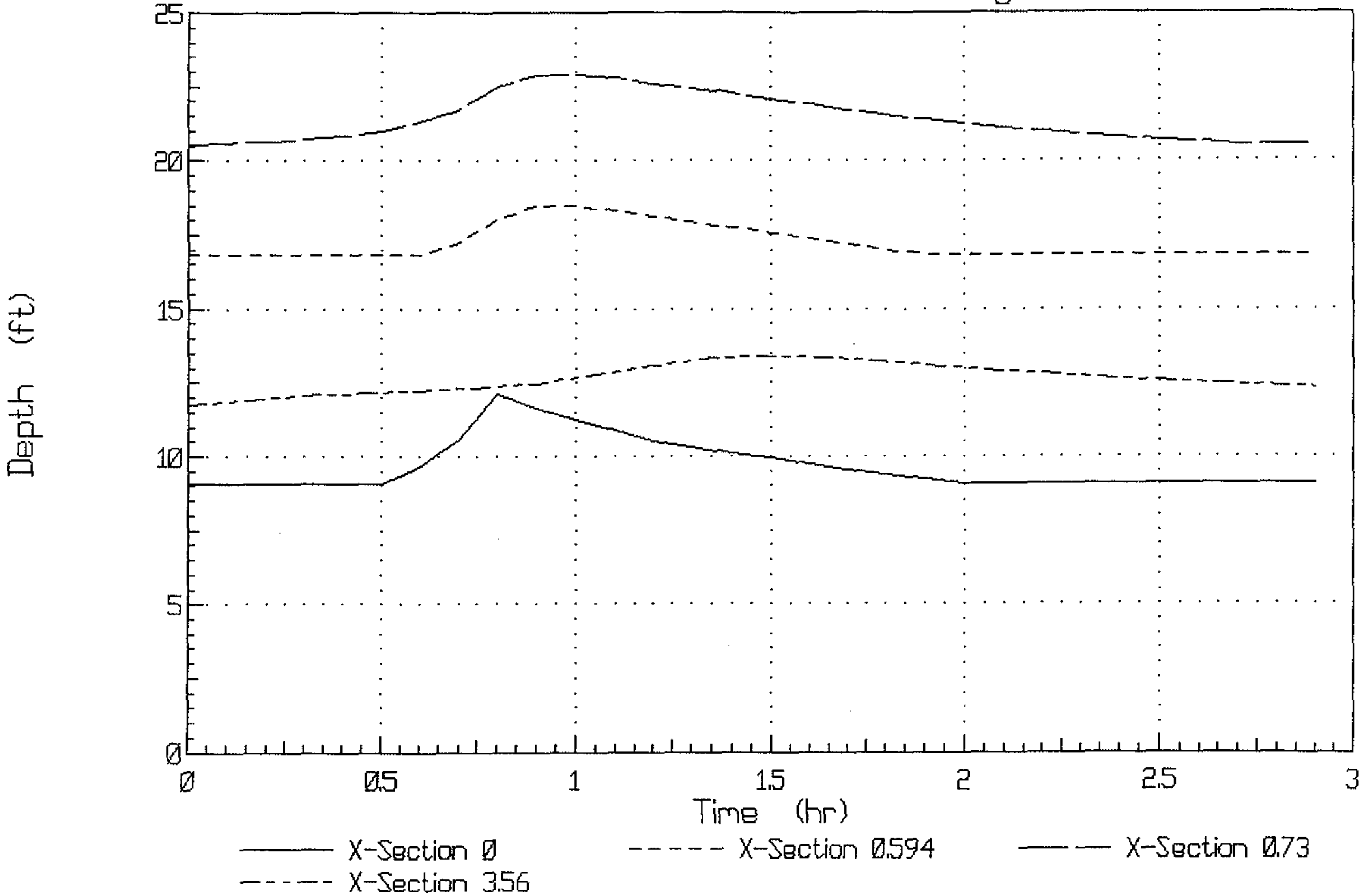
Combined Flow Depth Hydrographs
Chandler Pond Dam - Sunny Day Failure
Depth (ft)
Time (hr)
X-Section 0
X-Section 0.594
X-Section 0.73
X-Section 3.56

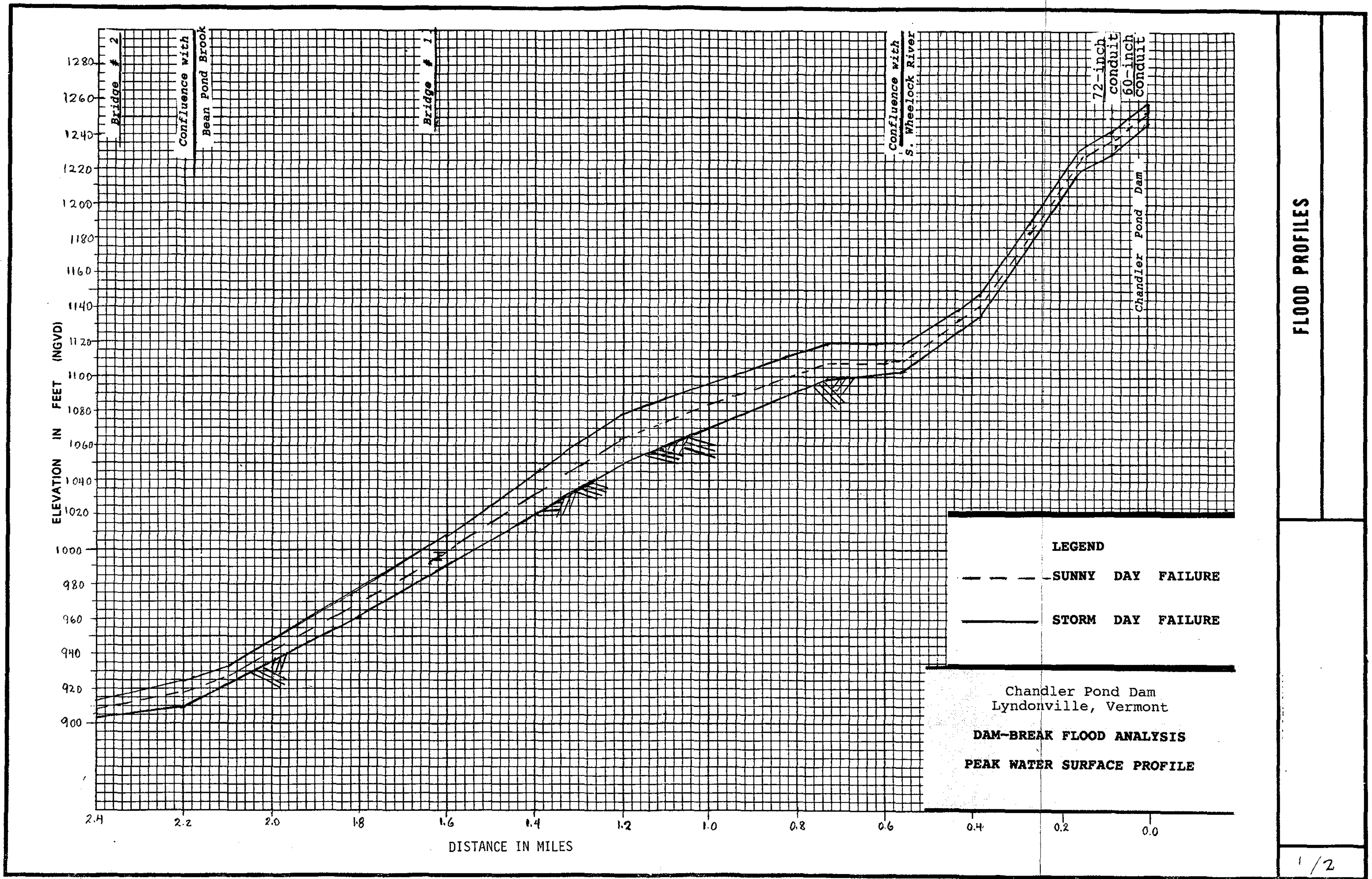


Combined Discharge Hydrographs
Chandler Pond Dam - Storm Day Failure
Discharge (cfs × 1000)
20
15
10
5
0
0
0.5
1
1.5
2
2.5
3
Time (hr)
X-Section 0
X-Section 0.594
X-Section 0.73
X-Section 3.56

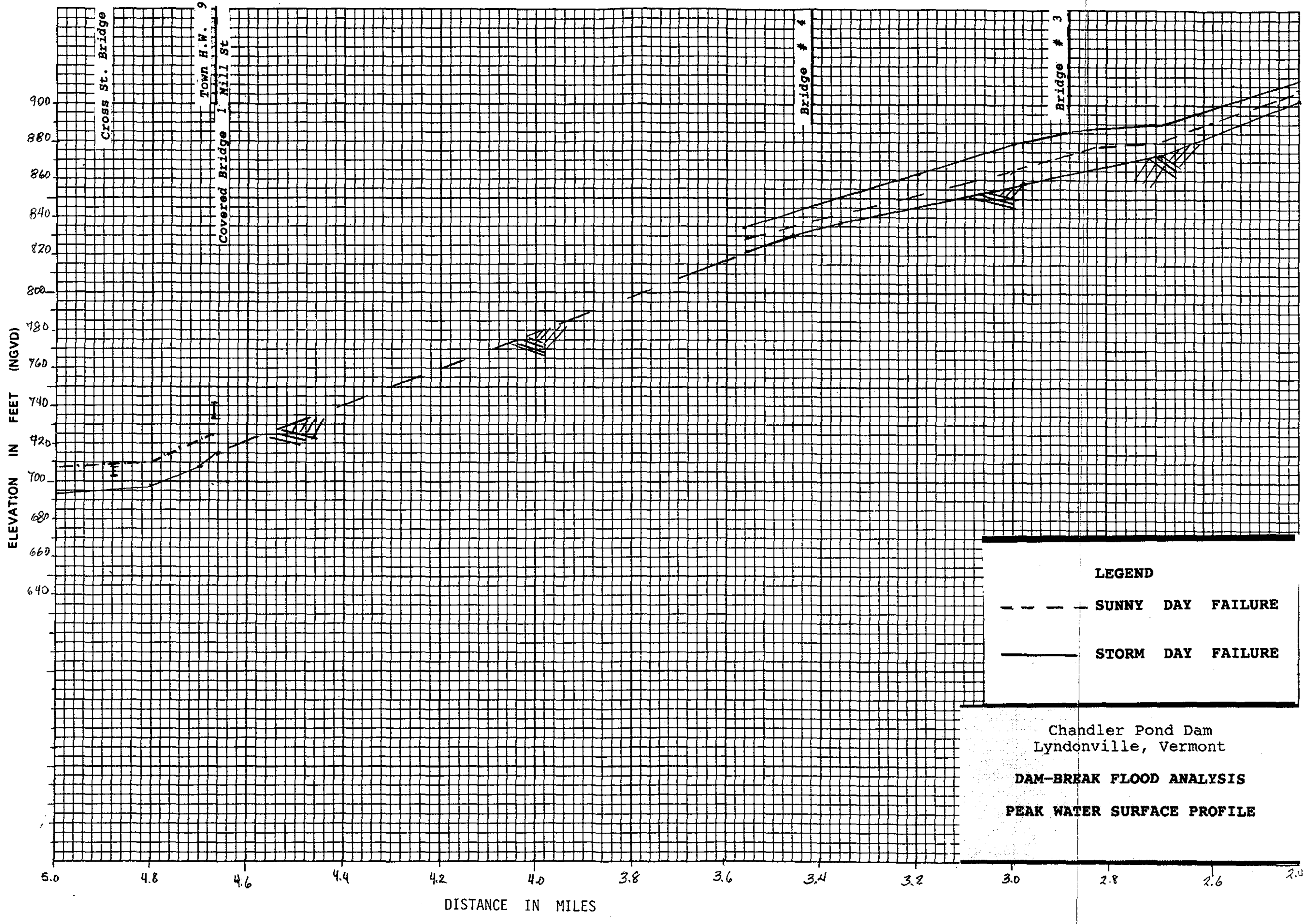
PLATE 6

Combined Flow Depth Hydrographs
Chandler Pond Dam - Storm Day Failure





FLOOD PROFILES
Bridge # 2
Confluence with Bean Pond Brook
Bridge # 1
Confluence with S. Wheelock River
72-inch conduit
60-inch conduit
Chandler Pond Dam
ELEVATION IN FEET (NGVD)
1280
1260
1240
1220
1200
1180
1160
1140
1120
1100
1080
1060
1040
1020
1000
980
960
940
920
900
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
DISTANCE IN MILES
LEGEND
SUNNY DAY FAILURE
STORM DAY FAILURE
Chandler Pond Dam
Lyndonville, Vermont
DAM-BREAK FLOOD ANALYSIS
PEAK WATER SURFACE PROFILE
1/2



Chandler Pond Dam
Lyndonville, Vermont

DAM-BREAK FLOOD ANALYSIS

PEAK WATER SURFACE PROFILE

FLOOD PROFILES

2/2

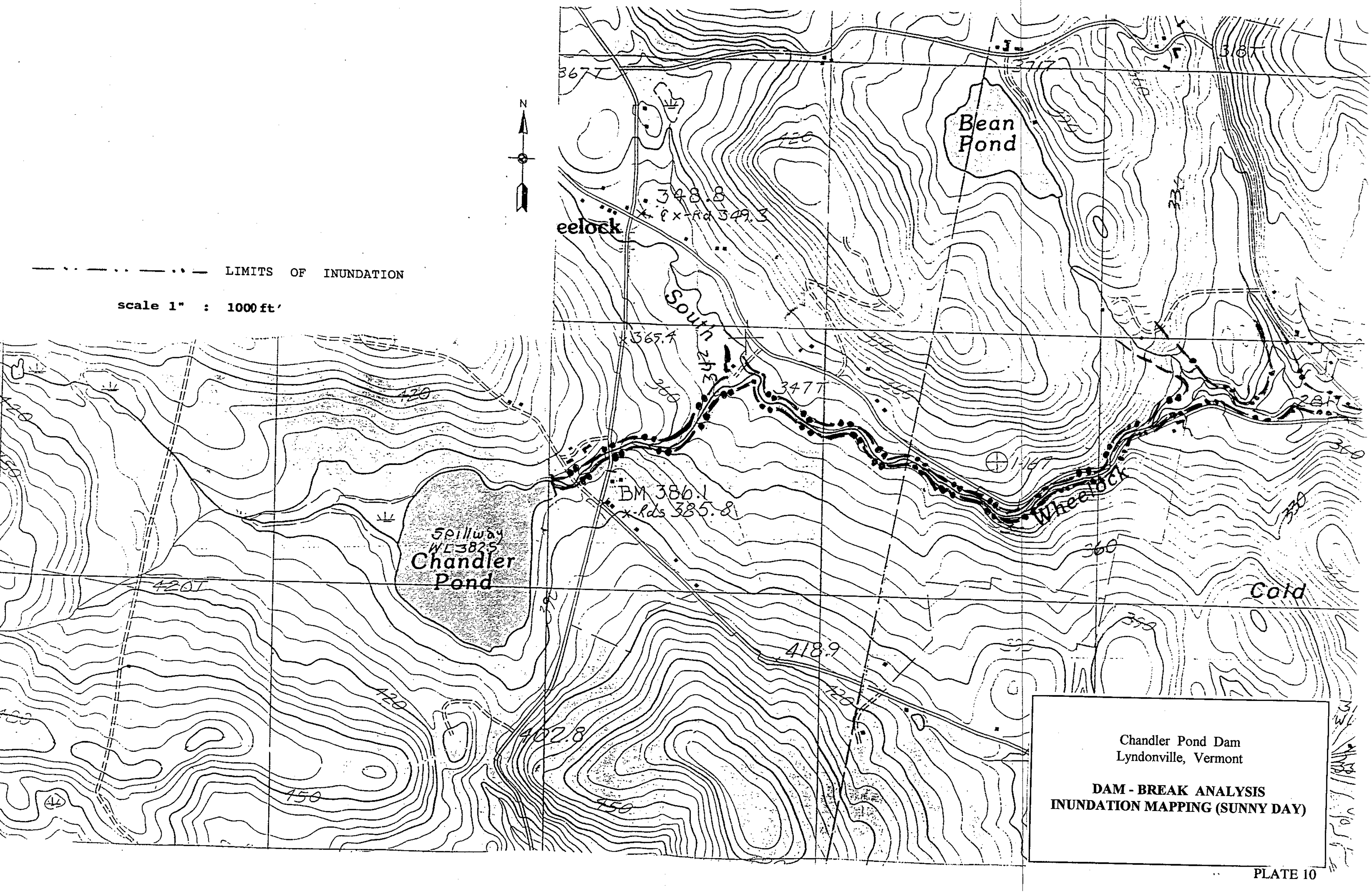
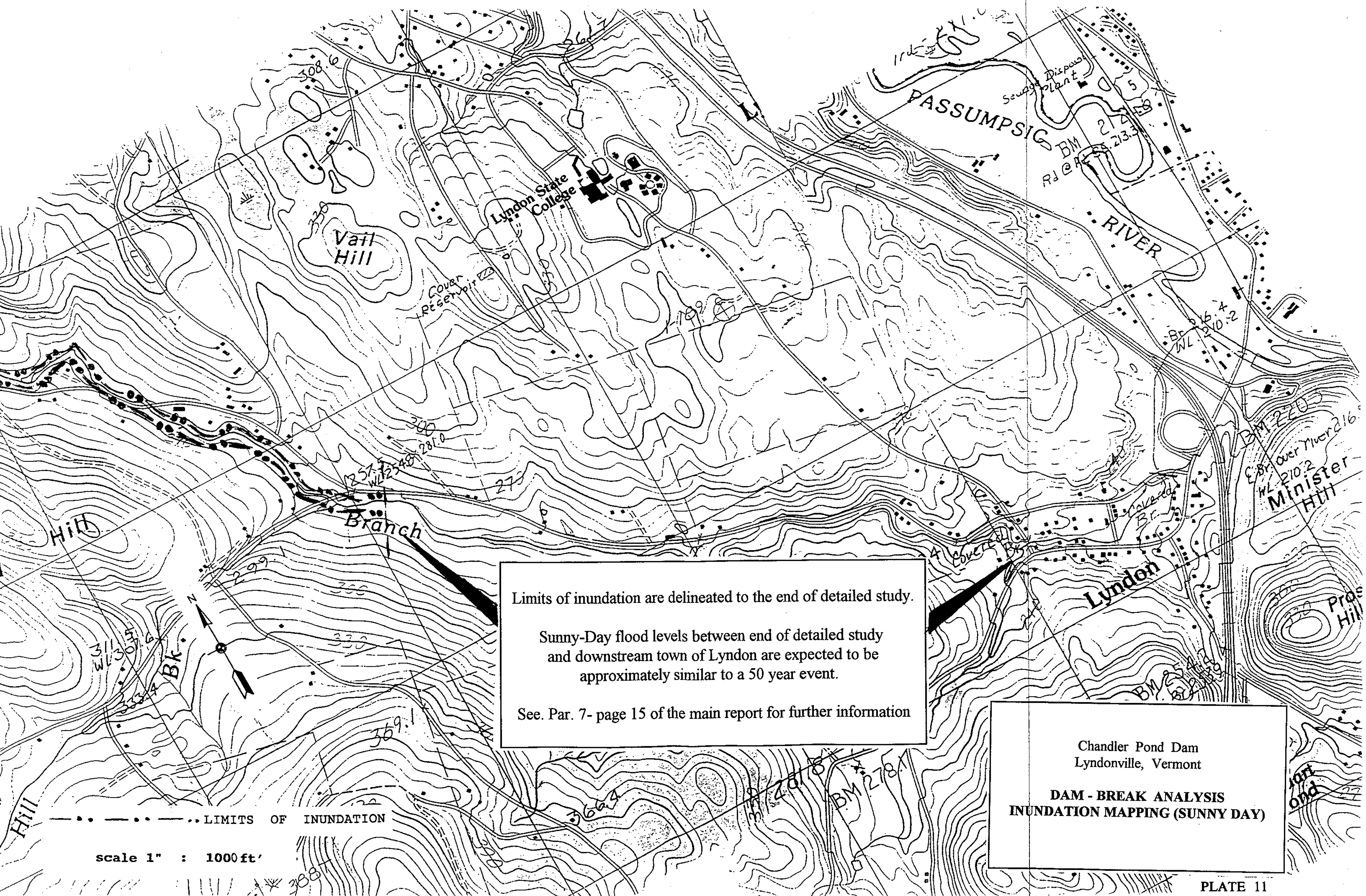
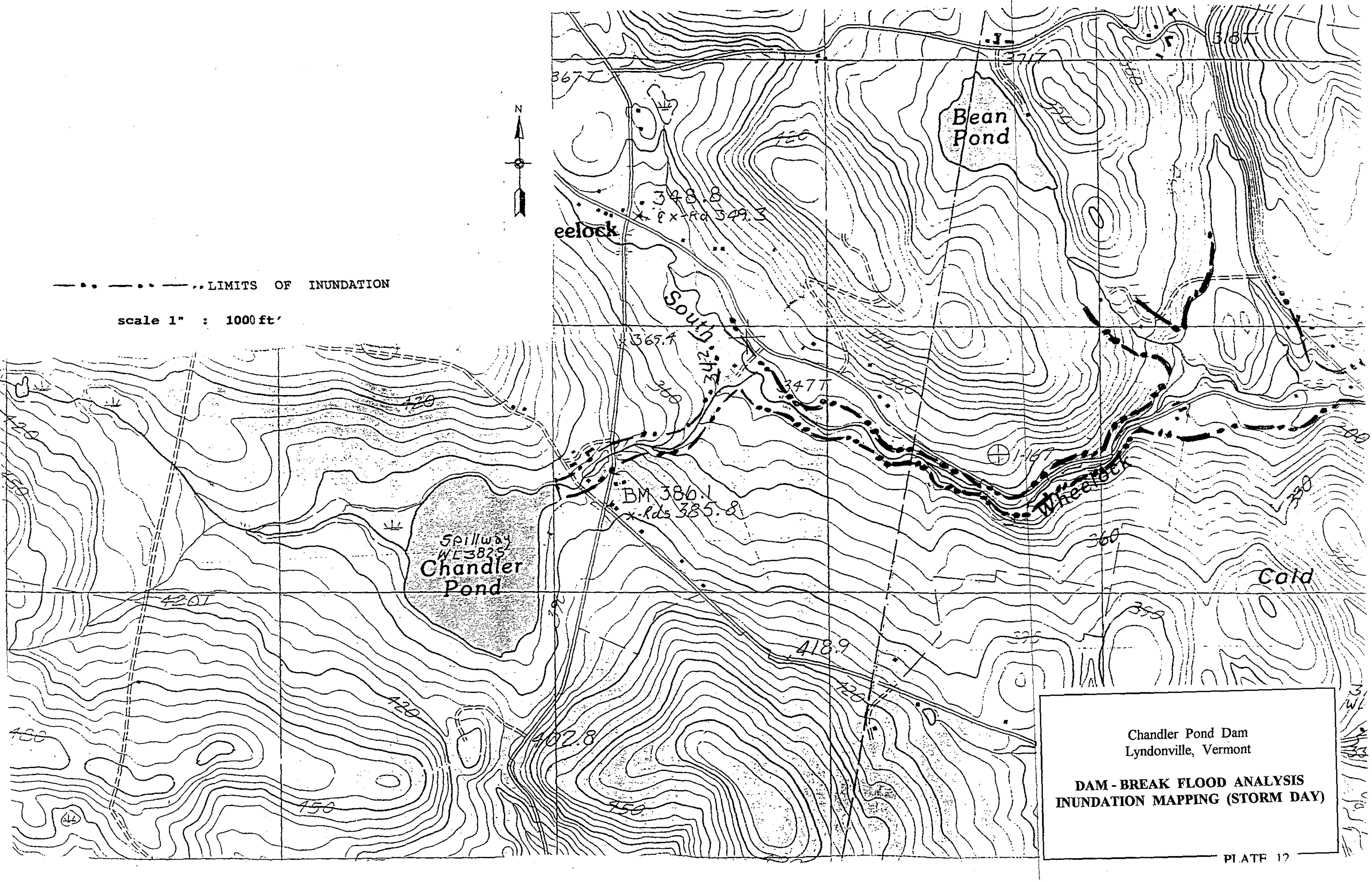

N
LIMITS OF INUNDATION
scale 1" : 1000 ft'
Bean Pond
eelock
South
Chandler Pond
Spillway WL 382.5
Wheelock
Cold
348.8
BM 386.1
418.9
402.8
Chandler Pond Dam
Lyndonville, Vermont
DAM - BREAK ANALYSIS
INUNDATION MAPPING (SUNNY DAY)

PLATE 10


Lyndon State College
Vail Hill
Cover Reservoir
PASSUMPSIC RIVER
Sewage Disposal Plant
Branch
Bk
Hill
Lyndon
Minister Hill
Covered Br.
Limits of inundation are delineated to the end of detailed study.
Sunny-Day flood levels between end of detailed study and downstream town of Lyndon are expected to be approximately similar to a 50 year event.
See. Par. 7- page 15 of the main report for further information
LIMITS OF INUNDATION
scale 1" : 1000ft'
Chandler Pond Dam
Lyndonville, Vermont
DAM - BREAK ANALYSIS
INUNDATION MAPPING (SUNNY DAY)
PLATE 11



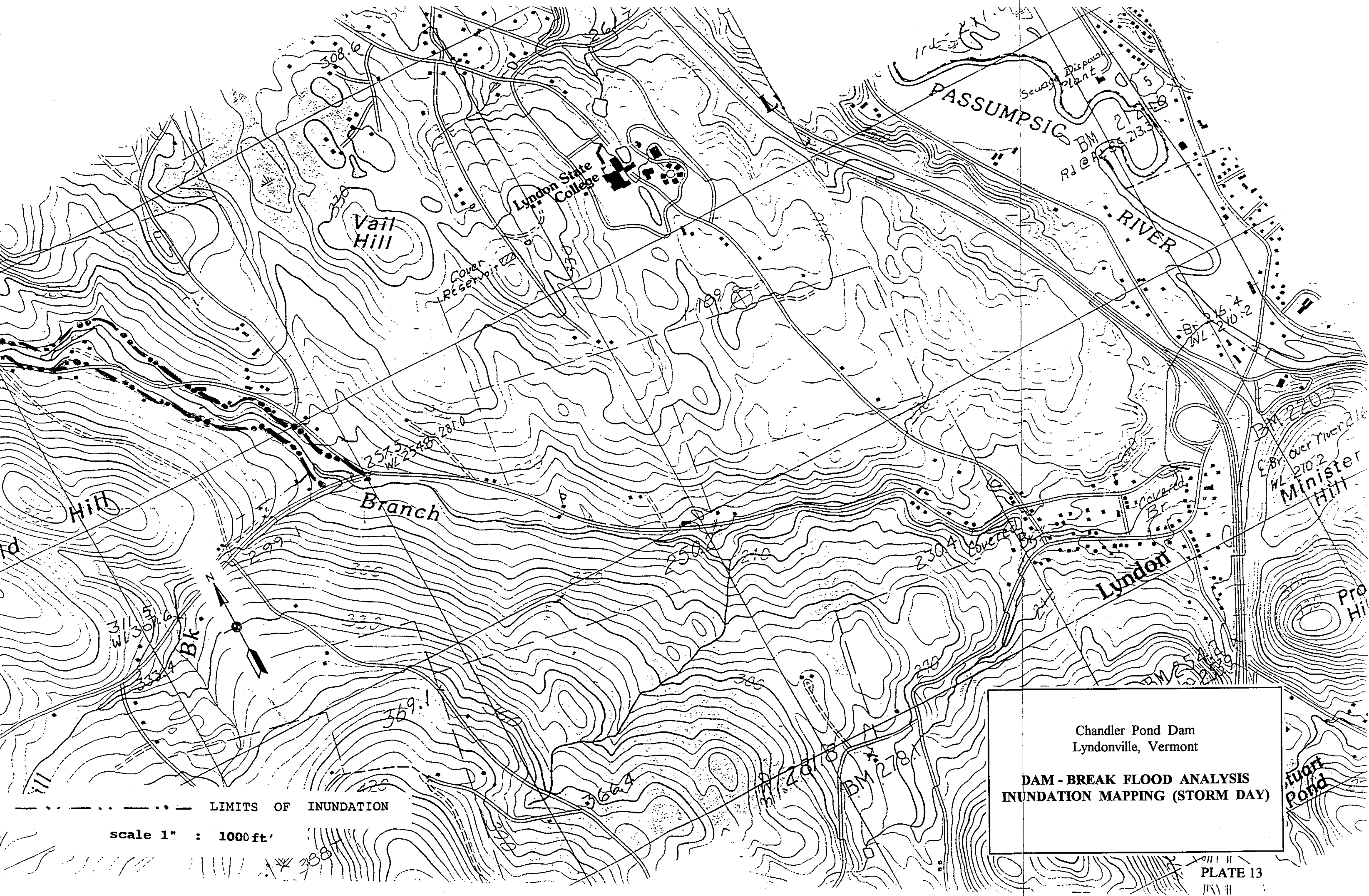
—·· —·· —··LIMITS OF INUNDATION

scale 1" : 1000 ft'

Chandler Pond Dam
Lyndonville, Vermont

DAM - BREAK FLOOD ANALYSIS
INUNDATION MAPPING (STORM DAY)

PLATE 12



Chandler Pond Dam
Lyndonville, Vermont

DAM - BREAK FLOOD ANALYSIS
INUNDATION MAPPING (STORM DAY)

PLATE 13

EMERGENCY ACTION PLAN
FOR
CHANDLER POND DAM

1. INTRODUCTION

a. Purpose. This Emergency Action Plan (EAP) is a suggested procedural outline indicating appropriate steps to be taken in the event of an impending failure of Chandler Pond Dam. This EAP lists phone numbers of certain local and State officials to contact in case of an emergency.

NOTE: The basic outline and Inundation maps in the report can be used by the dam owner in developing a more comprehensive EAP with the involvement of local an State Emergency Management personnel. A more comprehensive EAP would establish additional protocols for monitoring, notification, warning, evacuation and other emergency response measures.

b. Items in the EAP. Following are major items which should be addressed by the owner of the dam:

Monitoring
Evaluation
Prevention
Warning

2. MONITORING

a. Purpose. Having a person monitor the dam in the event of an impending failure, is the first step in implementing the EAP. During periods of heavy precipitation, flooding, or any unusual hydrologic event that might cause structural damage to the dam, the owner should have qualified personnel monitor the dam. The owner should assume responsibility for having the monitor at the dam within a reasonable time, and for providing an adequate communication system between the monitor and local officials.

b. Designated Monitor (to be completed by owner)

Name:
Address:
Phone: Home: ( ) -
Work: ( ) -

c. Type of Training. The owner should provide proper training so the monitor will have sufficient ability to recognize the condition of the dam, and be able to identify and evaluate specific problem areas. This training should be extensive enough to allow the monitor to describe conditions to local officials.

d. Communication System. The owner should provide primary and secondary communication systems between the dam monitor and local officials.

(1) Primary System: Normal telephone communication. The monitor should have access to the nearest available telephone and have on his person phone numbers of all appropriate local officials.

(2) Secondary System: Shortwave radio. If the phone system is out of order, the monitor should have access to a shortwave radio that can be monitored by local officials with scanners.

As an alternative to this system, if any local officials live within a short distance of the dam, the monitor could drive to one of their residences if the roads are passable.

SAFETY FIRST - Do not take chances that will jeopardize personal safety. Observe conditions at a distance if difficult or dangerous to investigate.

3. EVALUATION

a. Purpose. In conjunction with the ability to assess condition of the dam, the monitor should have the ability to determine and evaluate the nature of any existing problem. This evaluation is a crucial step, because failure to accurately and promptly identify a problem may adversely affect the EAP warning system.

b. Check List of Unusual Events or Conditions. Following is a check list of items that the monitor should use for assistance in preparing a safety assessment of the dam. The Vermont Emergency Management Agency should be contacted immediately if any of the following conditions are noted.

(1) Increased leakage or seepage at the toe of the embankment.

(2) Muddy leakage or seepage which would indicate that the earth fill in the dam is piping and the toe filter is not functioning properly.

(3) Leakage or seepage in the spillway are evidence of cracking, spalling or recent dam movement and instability.

(4) Obstruction or buildup of debris on the spillway.

(5) Any other unusual or unexplained conditions.

4. PREVENTIVE ACTION

a. Purpose. This section addresses actions that the monitor can take to help prevent an overtopping failure of the Chandler Pond Dam.

b. Maintenance. The monitor should ensure that the spillway is kept clear of debris during normal conditions. In the event of flooding, the monitor should take reasonable steps to ensure that the spillway does not become blocked with debris so that it can carry its full capacity.

> SAFETY FIRST - Do not take chances that will jeopardize personal safety. Observe water levels and other conditions at a distance if high water levels make access to the gate or dam difficult or dangerous. Do not take chances in trying to remove debris with high water conditions.

5. WARNING

a. Purpose. If the monitor feels that possible failure of Chandler Pond Dam is imminent, he/she should immediately notify the Vermont Emergency Management Agency, or other designated contact, who in turn will contact other officials (Section C) and downstream residents (Section D), and implement a warning/evacuation plan. If possible, the monitor should return to the dam and provide continuing surveillance, and report to the emergency management officials as appropriate.

b. Dam Failure Imminent. The monitor should evaluate if Chandler Pond Dam is in imminent danger of failure from any of the following conditions:

(1) Portions of the earth embankment start to wash out.

(2) Sudden or ongoing movement of the dam.

(3) Cracking or breakup of the concrete spillway

(4) Rapid development of a major leak.

c. Officials to Contact (As of October 1996). Officials at the Vermont Emergency Management Agency office can be reached 24 hours a day. During normal business hours, the receptionist at the office will locate the current duty officer. During all other hours the phone connects to the Vermont State Police Department in Lyndonville, VT, which will locate the duty officer. In the event that the phone system has failed, any

Vermont State Police barracks or cruiser can reach the duty officer through its radio system. Any available shortwave radio or CB radio can be utilized to contact the nearest police barracks.

(1) Scott Townsend
Village Superintendent
Work : (802) 626-5468
Home : (802) 626-8130
Beeper : (802) 741-3556

(2) Emergency Management Coordinator
David Dill
Work : (802) 626-5834
Home : (802) 626-8971

(3) Town Clerk
Robert Lawrence
Work : (802) 626-5785
Home : (802) 626-8431

(4) Fire Chief
Gregg Hopkins
Work : (802) 626-3221
Home : (802) 626-1208

(5) Vermont State Police Chief
Lt. Phil Lombardy
Barracks : (830) 748-3111

d. Downstream Residents. To be filled out and periodically Updated by Dam Owner

Name	Phone Number